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STAND-ALONE DEVELOPMENT SYSTEM
USING A KIM-1 MICROCOMPUTER MODULE

Documentation of the stand-alone microprocessor development system used in the navigation sensor processor research at Ohio University is described.

by

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I. INTRODUCTION

In the process of developing a microcomputer-based instrument, the need for a development tool is essential. Here at Ohio University it was decided that a small microprocessor-based system was needed having the ability to:

- (1) Contain all or most of the interface hardware,
- (2) Be easy to access and modify the hardware,
- (3) Be capable of being strapped to the seat of a small general aviation aircraft, and
- (4) Be independent of the aircraft power system.

In addition the system must also have the ability, on site, to modify, save and restore any of the software. It must also have the ability to display software-derived results. Such a system has been developed here at Ohio University. Presently the system is being used to develop a low-cost Loran-C sensor processor, but it is not solely dedicated to this problem as can be described later. The system is designed such that the Loran interface boards may be removed and other hardware interfaces inserted into the same connectors. This flexibility can be achieved through memory-mapping techniques into the microprocessor.

This system therefore allows the availability of a microprocessor to solve a variety of engineering development problems.

This paper is intended to describe this microprocessor-based system in sufficient detail to allow the definition of a hardware interface design for use with the microprocessor system.

II. OVERALL SYSTEM DESCRIPTION

Referring to the system block diagram, Figure 1, the heart of the system is the KIM-1 Microprocessor Module. This microprocessor is based on the MOS Technology MCS6502. The KIM-1 board is described in the KIM-1 Applications Manual^[1] Briefly the microprocessor consists of the MCS6502 and two interface support chips. These support chips contain a keyboard and TTY monitor programs stored in read-only memory. Also included in the support chips are two programmable timers. One of the timers is dedicated to timing related to the monitor program and the other timer is directly accessible to the user. In addition to the functions described above, these support chips also contain two user-definable PIA ports. A total of 15 one-bit ports that can be defined under software control as either input or output functions. The use of these ports in the development system will be described later.

Included also on the KIM-1 board is 1K of random access memory available for user software development. The KIM-1 board also has the ability to save and restore user

written software on a common audio cassette recorder. This is accomplished by hardware contained on the KIM-1 board. The KIM monitor also contains software to drive the cassette interface. The KIM-1 board has two edge connectors through which all the expansion or application signals needed for external hardware are available.

Referring back to Figure 1, the next block described here is the 4K memory board.^[2] Figure 2 is the schematic of the memory board which has been modified to allow the interface with KIM. Essentially the memory board was designed to fit the S-100 bus structure but with a few wiring changes it works well with KIM. This added 4K of memory expands the available RAM to 5K bytes.

The next block to be described is the system interface board. This board contains the D/A converters, EIA interface circuit, auxillary audio amplifier, and a voltage-to-voltage converter to derive -12 volts for the D/A's and the TTY reader relay. This board also contains connections for easy access to the PIA ports and other microprocessor-related signals. Figure 3 is a schematic of the circuits contained on the system interface board. This board is constructed so that additional circuits relating to system interface can be accommodated.

In describing the three blocks marked, audio connector panel, switch panel and TTY/Asciscop connector it is easier to define their functions as necessary to the interface and control of the complete microprocessor system. The audio connector panel contains the switches that select the monitor peripheral as either the TTY/Asciscop or the KIM keyboard. The switch panel also contains switches to control the two interrupts to the microprocessor. There is also a switch to select as the audio monitor the cassette recorder or an external source connected to the input jack located on the system interface board. The TTY/Asciscop connector are actually two connectors, one for the Asciscop connections and the other for the TTY connections.

There are two blocks on Figure 1 labeled interface card 1 and interface card 2; these are actually connectors to cards that would contain the hardware to be interfaced with the microprocessor. These are the connectors for the on-board interface hardware. The connections to these connectors are essentially the same, as they contain all the signals necessary to interface to the microprocessor using memory mapping techniques.

The external interface connector is used to connect external interface hardware to the on-board interface hardware. The definition of signals on these lines is irrelevant as the lines could carry any defined signal from the interface card to the external interface connector. For example, let's say, one of the lines is defined as a Loran interrupt flag when using the Loran interface card. Then on removing the Loran interface card and replacing it with, let's say, the Omega interface card, the line that was previously defined as a Loran interrupt flag could now be defined as the Omega phase interrupt line. In this way a minimal amount of wiring changes are required to enable the microprocessor system to be used to develop other microprocessor-based system solutions.

The last block to be described briefly is the power supply. This is a three-voltage supply built in an external chassis from the microprocessor system. This was done so that

the weight and bulk of the supply would not get in the way of using the system. It also allows the supply to be located at some point away from the micro system. The power supply provides these output voltages to the micro system, +5 volts dc at 3 amps, +8 volts dc unregulated at 2 amps, and +12 volts dc at 1 amp. This power supply was also designed to provide these voltages from two different input power sources. The first and obvious source is the ac power line, the other is that this supply can also operate off a +12 volt battery pack. This allows the microprocessor system to operate in a vehicle, such as an aircraft, independent of the vehicles power source. The battery pack used will allow the power supply to operate in the field for several hours independent of the ac power line source.

III. KIM-1 MICROPROCESSOR DESCRIPTION

It is not the purpose of this paper to give a full operation and hardware description of the KIM-1 microprocessor module since that information is well documented.^[1,3,4] In terms of the capability and cost of the KIM-1 microprocessor, it is easy to see why this particular microprocessor module has proven to be a good choice for such a development system. The KIM-1 provides interface capability, significant on-board RAM, cassette interface, ROM monitor and on-board user input-output capability in the form of keypad and 7 segment display. All of this is provided on a single board requiring only a power source. Needless to say, this has made the development of the rest of this development system described in the paper presented here quite simple.

The only hardware modification to the KIM has been to install a temperature-compensated crystal oscillator instead of the supplied crystal provided on KIM. This was done so that there was not only a stable time base for the microprocessor, but also a stable source for some of the interface hardware. This was necessary for some of the research being conducted with this system at Ohio University.

IV. ON-BOARD INTERFACE CAPABILITY

Referring to Figures 4 and 5 of the wiring diagrams of the micro system notice that all of the necessary signals from the microprocessor have been included in the on-board interface connectors. This will provide the interface hardware the ability to communicate with the microprocessor via the data bus as if it were memory. This technique is commonly referred to as memory mapped addressing. This method of getting information to and from the microprocessor allows more flexibility, as required by this system than could the PIA ports already provided on KIM. The PIA ports can therefore be used for the transfer to control signals to and from the interface hardware and the microprocessor. For example control flags to the interface hardware. Going to a memory-mapped scheme also has the advantage that all interface hardware will fit the same interface criteria so that in system hardware development the interface scheme is already defined. This does not imply that the final product design need to be memory-mapped for as can be shown the software needed to drive a PIA is, with small modifications, essentially the same as memory-mapping. Simply, memory-mapping in the development does not necessarily compromise the micro/hardware interface that could be more cost-effective in the final design. This micro system is designed to simplify the development of a design not to limit it to a particular situation.

Also provided as on-board interface capability are two D/A converters. The circuitry for this is included in the on-board system interface card. See Figure 3. The inputs for the D/A converters are provided through the PIA ports on KIM. The D/A connected to PIA (a) is a full 8 bits, but due to the interrupt capability of the on-board programmable timer on KIM, only 7 bits are available for output to the D/A on PIA (b). This is due to the fact that PIA (b) bit 6 is used for the programmable timer interrupt request. The use of the PIA ports for the D/A's does not adversely affect their use because they can still be utilized for inputs and outputs provided that the drive capability is not exceeded.

In addition to the D/A converters there is also provided a small audio amplifier stage that can be used with a hardware interface for a signal monitor or signaling device. The circuit for this is also shown in Figure 3.

One example of a hardware interface built for one of the on-board interface connectors is a Loran-C digital work generator.^[5] This is currently one of the uses that this micro-computer-based development system has for us at Ohio University.

V. EXTERNAL INTERFACE CAPABILITY

In describing the external interface connections refer to Figures 4 and 5, the system wiring diagram. The external interface connector is a standard RS 232 (25 pin) female connector. This connector is available to facilitate connections to existing hardware external to the KIM development system. Note that all of the 25 connections are available to both of the on-board interface connectors. Also the only two pins of the external interface connector that are dedicated are the ground and +5 volt power. This connector is very flexible because it is not defined in any particular way to the microprocessor or its control signals. This allows external hardware to interact with the microprocessor via on-board interface hardware. Another advantage is that signals on the external interface connector are defined only for a particular on-board interface card which allows the microprocessor system to be defined for many possible development systems without the need for rewiring.

VI. MONITOR INPUT OUTPUT CAPABILITY

Interaction between the user and the microprocessor via the monitor program on ROM can be achieved by three means. First to be considered is the keyboard and 7 segment display provided with KIM. All the monitor functions provided for in the monitor are available using the keyboard and display on KIM. These functions are described in the KIM-1 Applications Manual.^[1] Also provided by the KIM monitor is a TELETYPE monitor that allows the user to interact with KIM through the keyboard, reader and printer of a standard 20 ma current loop TTY. In addition the KIM can interface with any standard device using the EIA standard communications scheme. This is accomplished through the EIA level shifting circuits available on the system interface board. This circuit consists of a 20 ma to EIA level shifter. (Refer to Figure 3). For both additional methods of user interface the full capability of the KIM monitor is available. This allows many different development methods.

Of particular note is the KIM 7 segment display. This can be used to display user-developed software results without the need for a large bulky display device requiring an

ac power source.

VII. POWER SUPPLY

This is the entire power source for the KIM micro system. It provides direct current voltages for the various parts of the system. The sources available from the power supply are: +5 volts at 3 amps regulated, +8 volts dc at 2 amps unregulated, and +12 volts dc regulated at 1 amp. These voltages can be provided by the supply from two different sources, the 115 vac power line or a 12 volt battery capable of about 10-15 amp hours of energy. This should provide about 3 hours of service from the microprocessor development system with a fair amount of interface hardware. The schematic for the power supply is contained in Figure 6. In the circuit transistor pairs Q1, Q2; Q3, Q4; and Q7, Q8 form darlington amplifiers for the series pass elements of the supply. For the +8 volt supplies, the reference is derived by a constant current source, Q6, providing current to the 3 volt zener diode. This voltage node is used to provide the reference voltage for the +5 and +12 volt reference amplifiers made up to two sections of an LM324 single supply operational amplifier. Feedback is provided to the reference amplifiers by voltage dividers on the supply outputs. The voltage supply for the LM324 op-amp is provided by the zener referenced emitter follower, Q5. This provides a stable source voltage for the op-amp. Switch 1 provides the power on-off function. Switch 2 determines whether the supply is operating from the line source or battery source. The input transformers and the output series pass transistors are protected by fuses. The supply connects to the main system chassis via a cable with 15 pin connectors on each end.

VIII. SUMMARY

As a final note again I would like to point out that this microprocessor-based system was designed with the idea that a development tool is needed that could provide the means to apply a microprocessor to the solution of a particular engineering problem. The system described here is one possible means of designing such a development system. Most of the real development system design is already available through the use of the KIM-1 microprocessor module. The parts of the system that are added are the engineering concepts of portability and the ability to operate independent of the 115 vac power source. These are significant needs for the use as a development tool at Ohio University. This system provides a means for quick turn-around in the development of both hardware and software. Also worthy of note is the fact that this system is not dedicated to a particular hardware application. This is significant because the cost involved in building this system can be spread out among several different development programs, thereby making it quite economical.

In conclusion I would like to point out that much of the power of this system is derived from the completeness of the design of the KIM-1 microprocessor module.^{11,3,4} This microprocessor is almost by itself a stand-alone development tool. The addition of the hardware described in this paper vastly increases this already useful tool.

IX. REFERENCES

- [1] KIM-1 MICROCOMPUTER MODULE USER MANUAL, MOS Technology, Inc., August 1976.
- [2] SD SALES 4K MEMORY MANUAL, SD Sales Company, January 1976.
- [3] MCS6500 MICROCOMPUTER FAMILY HARDWARE MANUAL, MOS Technology, Inc., January 1976.
- [4] MCS6500 MICROCOMPUTER FAMILY PROGRAMMING MANUAL, MOS Technology, Inc., January 1976.
- [5] LORAN-C DIGITAL WORD GENERATOR FOR USE WITH A KIM-1 MICRO-PROCESSOR, J.D. Nickum, NASA TM-54, December 1977.

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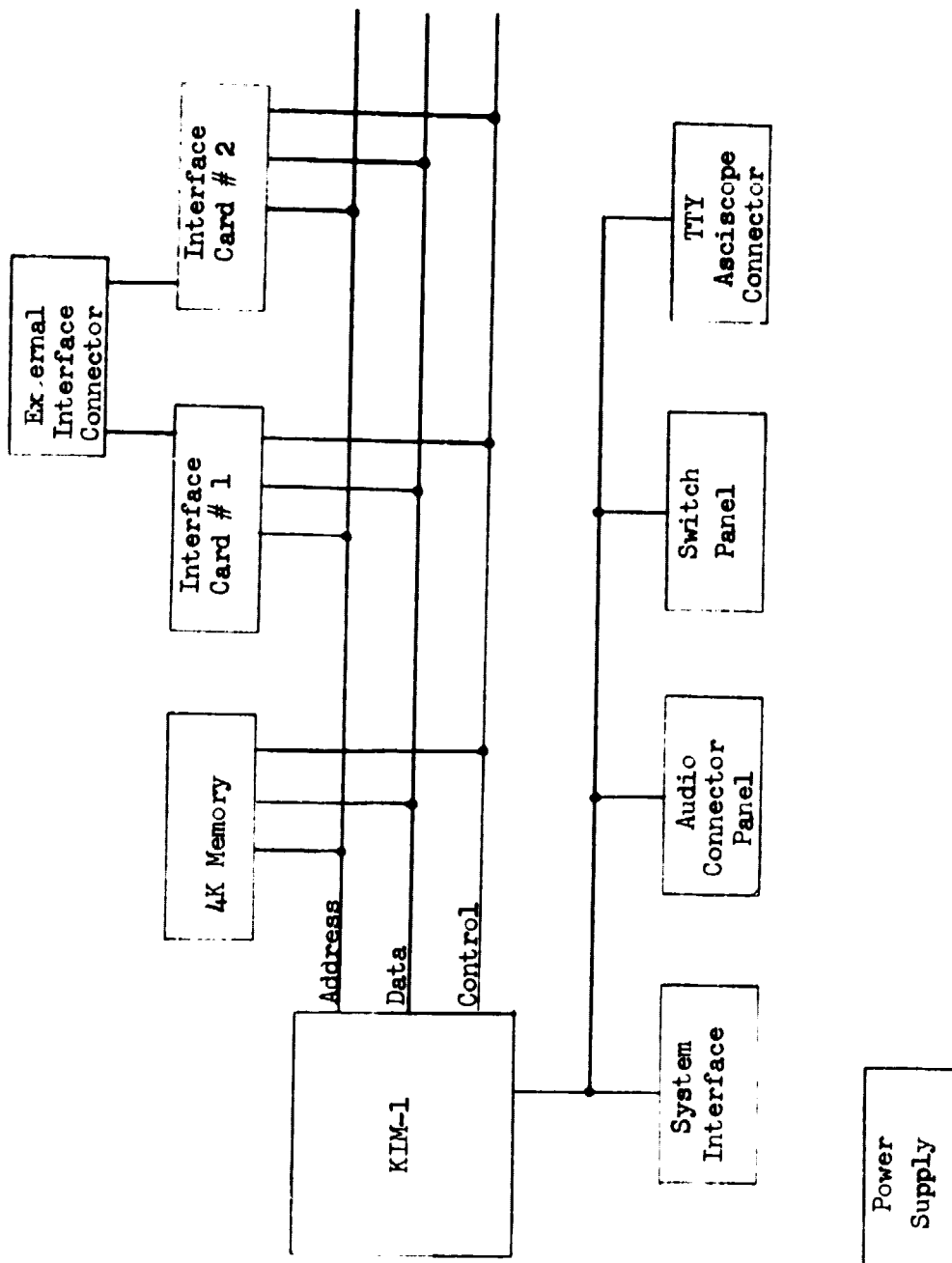


Figure 1. System Block Diagram.

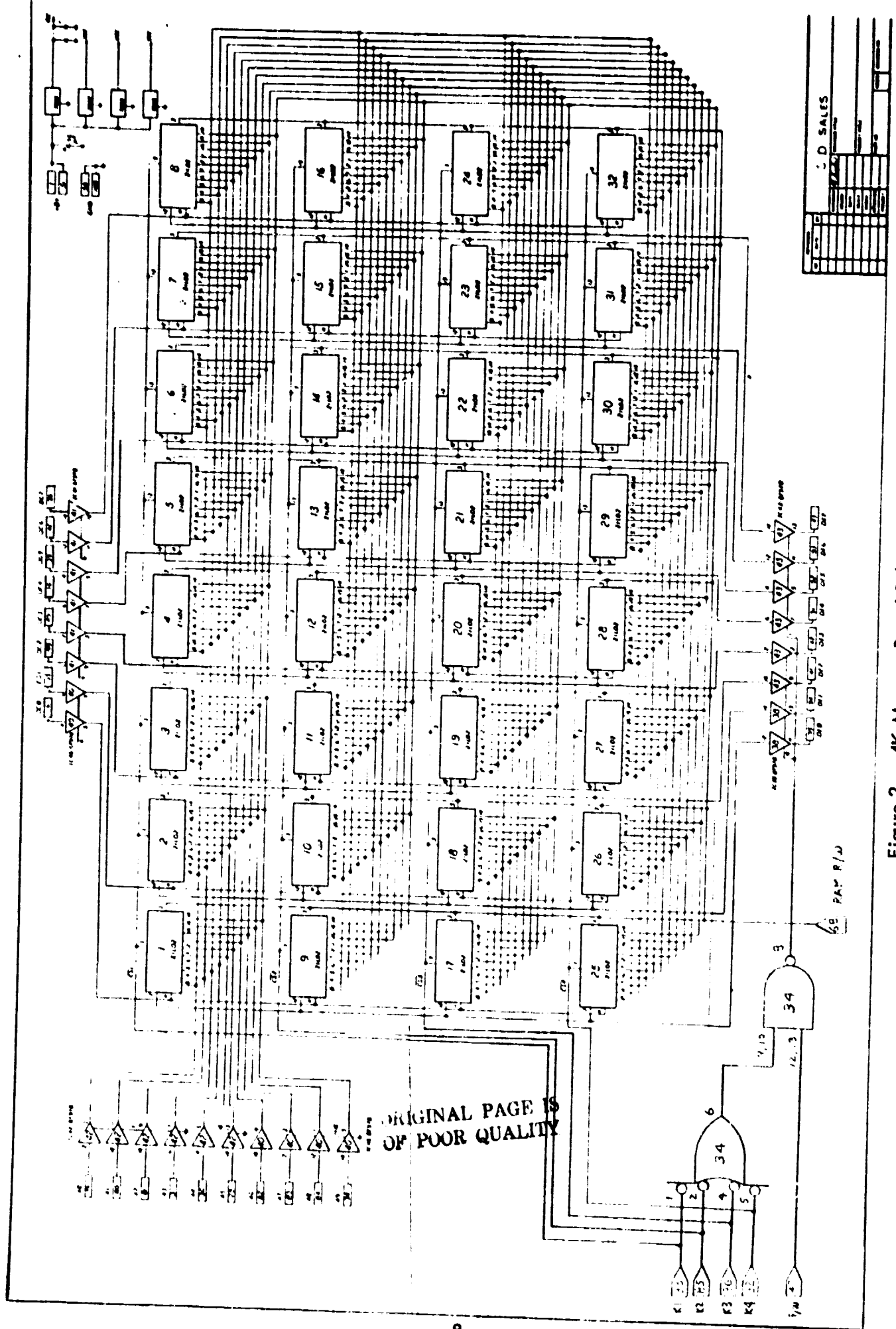


Figure 2. 4K Memory Board Schematic.

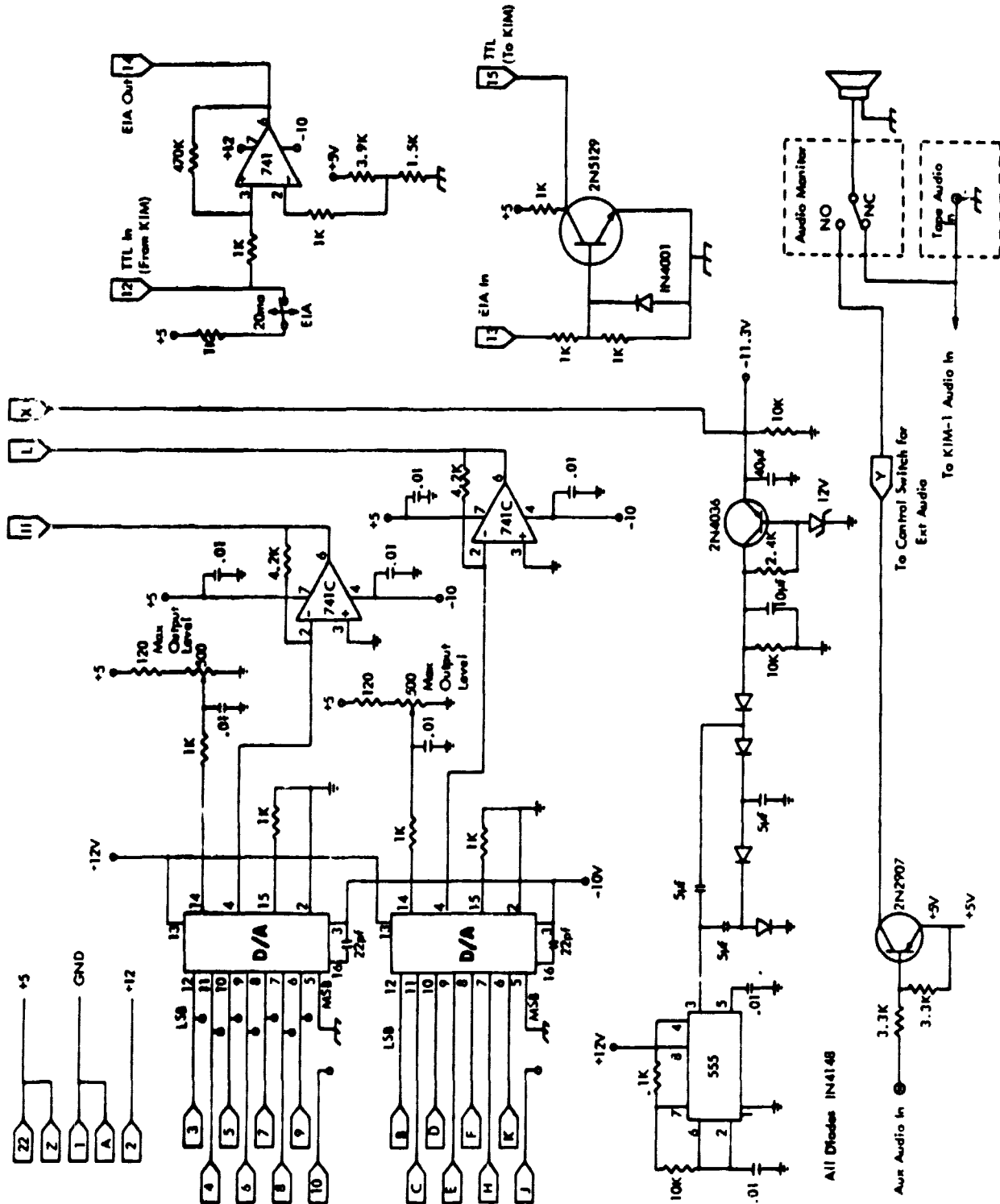


Figure 3. System Interface Board Schematic.

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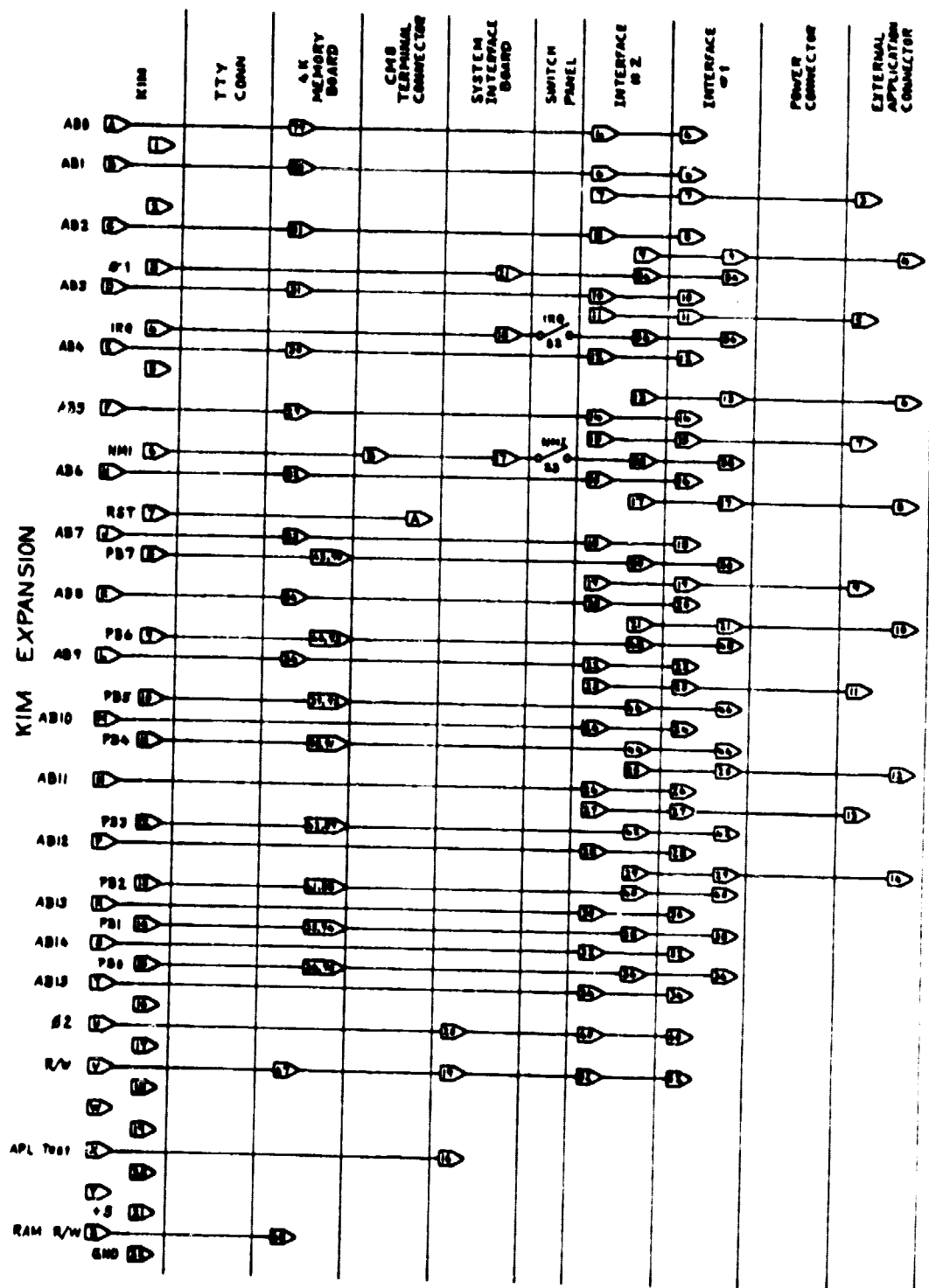


Figure 4. System Wiring Diagram - KIM Expansion.

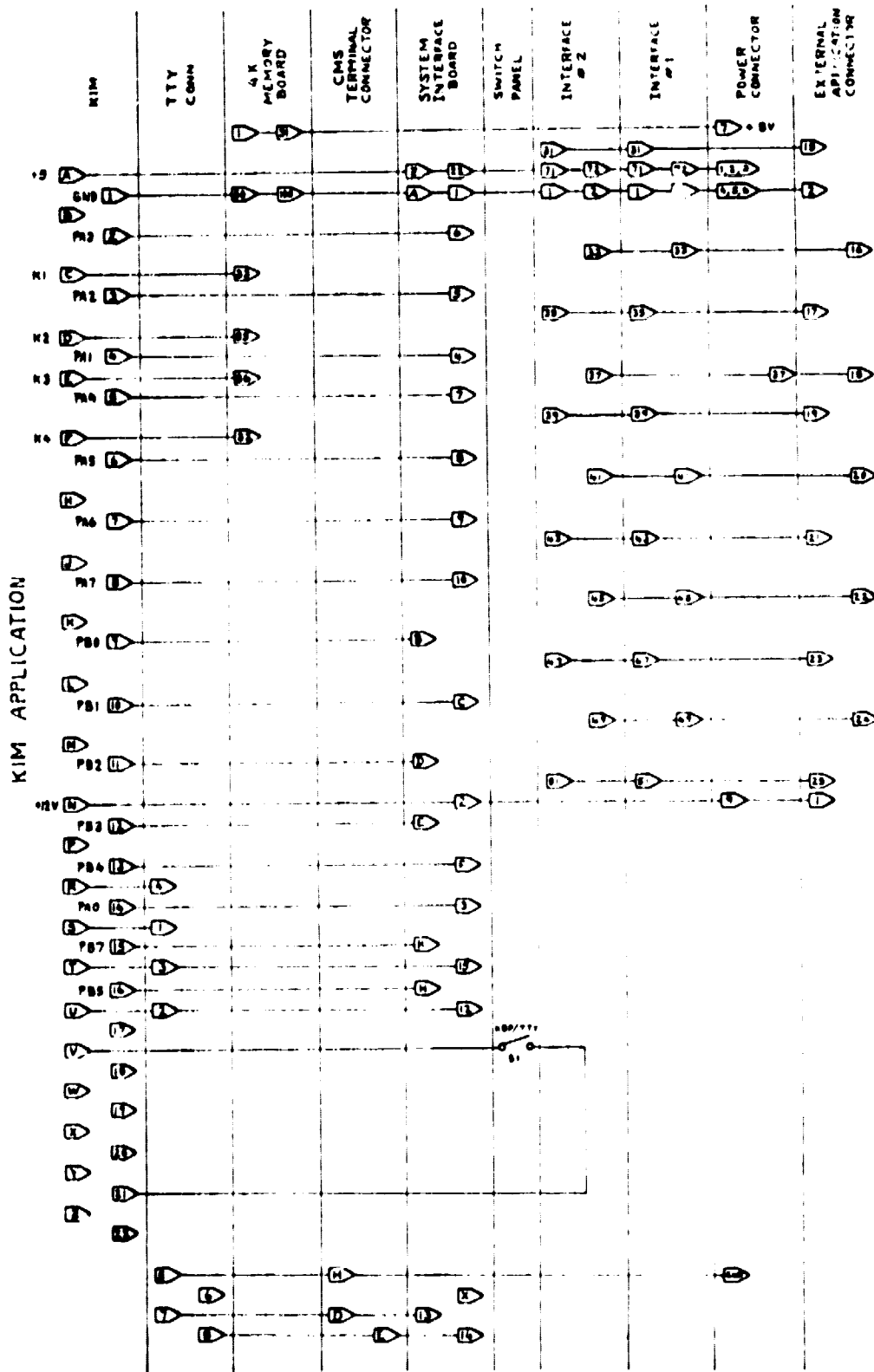


Figure 5. System Wiring Diagram - KIM Application.



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